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Vol. IV November 1915 No. 8

EDITORIAL

The Application of Science to our Agriculture.

The above is the translation from Spanish of the topic of a paper read before the recent Agricultural Congress by Mr. Inocencio Elayda who is Instructor in Agronomy and Farm Foreman in the College of Agriculture. Mr. Elayda's speech has been published in full in the August issue of the *Revista Economica*, and dealt mostly with present conditions in farm engineering, agronomy, and animal industry in the Islands.

Speaking of agricultural engineering, the author pointed out that almost nothing has yet been accomplished toward the use of modern agricultural implements. In the writer's words, "it is indispensable to formulate and carry out a comprehensive plan whose object is to make a scientific study of the economy, efficiency, and adaptability of Philippine agricultural implements, including the plow, hoe, harrow, sickle, and other native implements and that an exact study be made of the economy, efficiency, and adaptability to different local conditions of modern machinery including hoe, plow, harrow, roller, thresher, winnower, scythe, sifter, combined reaper, binder, and other supplementary implements of various types." Such a study, he claims, is necessary before recommendations can be given as to the introduction and use of modern implements and machines.

Under agronomy, Mr. Elayda sees in diversified farming a way of evading different enemies and troubles of the farmers. He believes that under normal conditions, several crops can not fail at the same time. The investigation of the methods of cultivation and other farm conditions in the Philippines, seed selection, distribution of selected seeds, instruction of the farmers in the conservation of soil humidity and soil fertility are among the means which he enumerated by which, he states, the government can help the farmers. It may be remarked that the College of Agriculture is actively engaged in this kind of work. One of our last year's graduates studied the cost of rice-production

by Philippine methods in the towns of Los Baños, Calamba, and Calauang, Laguna province, and found out, among other things, that in tenant work the profit goes to the land owner, in double tenantry it goes to the land owner and head tenant, and that it is the exorbitant interest rates imposed upon the small farmers that most increase the cost of rice-production. The College is in constant receipt of requests for seeds. Among thesis-students this year, three are working in rice-selection and one in rice-fertilization. Their work is done in native rice fields so that their operations are of high demonstrative value.

Commenting on horticulture, Mr. Elayda states that during the past fifteen years no improvement has been made in this branch of agronomy. He says "nothing permanent has been done to combat the diseases of the coconut, to restore the coffee industry, to increase the cacao plantation or to improve the production of our fruit trees." He suggests the employment by the government of trained and capable plant pathologists and economic entomologists which he claims will undoubtedly result in greatly benefiting the farmers in particular and the whole country in general. To support his contention, he cited the work of the Sugar Syndicate of Hawaii in employing entomologists to combat the cane leaf hoppers, by which millions of dollars are saved every year. Incidentally, the Sugar Planters' Association of Hawaii has sent to the Philippines an entomologist, Mr. Frederick Muir, to study the means of eradicating the insect larva which attacks the roots of the Hawaii sugar cane. His quarters are at the College of Agriculture. It is our impression that the government has already in contemplation the hiring of scientists to handle plant diseases here. But we want to caution the general public beforehand from falling into the error of expecting immediate results, for investigation of difficult scientific problems elsewhere has required many years of labor.

Our animal industry, the author considers as an entirely neglected branch of agriculture. Nothing effective has been done towards the eradication of animal diseases. In spite of the carabao being the most important work animal that we have, the indispensable companion of the Filipino farmer, no attempt has been made to improve it by the establishment of different types and by the selection and crossing of different breeds. It may be remarked, however, that since Mr. Elayda's speech before the Congress of Farmers, we have published in our preceding issue the result of the only study so far of the Philippine carabao, which was undertaken by a senior student of the College of Agriculture without any government fund for the purpose. As a result of this study, there have already been established five types of carabao. Results of this kind are of fundamental importance to carabao breeding, but the investigation has covered only so insignificant a portion of the field of investigation that it has to be continued to be of practical value. Investigations of important phases of the poultry and hog industries are also under way in this College.

After speaking at length about the conditions of our farm engineering, and the agronomy and animal husbandry side of our agriculture, and after pointing out how science can be applied in their improvement and development, the writer appealed for a symmetrical agricultural development. He states "that no matter how much we talk and do for the cause of irrigation and agricultural credits, these must maintain a strict and direct relation with questions of farm implements, of agronomy, of animal industry, and of plant and animal diseases."

A Study of Native Coffee Production

By Fernando D. Luistro

Thesis presented for graduation from the College of Agriculture, No. 38.

A comparatively few years ago the Philippines ranked high in coffee export, while they now export practically none, but, on the other hand, import largely. The coffee plant is subject to various diseases (1), among which the most destructive is that caused by *Hemileia vastatrix*, a microscopic fungus which, about 1870, ruined the plantations of Ceylon. It was equally destructive in Java, and elsewhere, as well as in the Philippines. The introduction of *Hemileia vastatrix* here, though the means by which it was accomplished are not definitely known, seems likely to have been by the way of the southern islands from Java or Singapore in the early part of the ninth decade of the last century. By 1885-1886, it had spread throughout the great coffee-growing region of Batangas and Cavite, and, by 1890, the coffee was practically wiped out as a commercial proposition.

Had the Philippines possessed effective quarantine measures and regulations regarding the importation of plants, in operation at the time of the introduction of this disease, there is no doubt that it would have saved millions and millions of pesos to the coffee grower.

Because coffee was the source of considerable wealth in the sections in which it was cultivated, it is worth while to investigate thoroughly the possibility of re-establishing this industry. The Philippines present perfect natural conditions for growing this crop and the product is not excelled elsewhere in the world in its quality. There are obvious reasons why the cultivation will soon receive serious attention in the Philippines. We have the latitudes, altitudes, climates, and all qualities of soil most favorable for its culture. The hilly areas of the Philippines whose soils are friable, deep, and well drained and enriched by washings from above, offer especial inducements for the cultivation of coffee. The mountain slopes ranging from 1000 to 4000 feet above the sea level offer the most excellent locations, though it gives a fair yield even at sea level. In the second year after transplanting to the field in the Philippines, the trees show signs of fruiting, and by the third year will produce a fair crop.

Now-a-days sufficient coffee is grown throughout the Islands to prove that it is far beyond the experimental stage. There is no reason why Mindanao and other islands in this Archipelago can not produce as high grade coffee as that produced in Java, and this industry made that island famous. Mindanao and Java are at about the same distance from the equator. The fact that Mindanao is north of the equator while Java is south of it, is no reason why they can not be equally good as coffee producers. There is also no reason why the diseases of coffee in these Islands should be more serious than those in other islands in the same latitude.

The Dutch planters, after their industry had been wiped out, found ways of rehabilitating the industry. Search was made for a coffee resistant to *Hemileia vastatrix*, and *Coffea liberica* and *Coffea robusta* were as a result brought into culture in Java. Later they produced a number of valuable hybrids. After a long period of efforts the restoration of their industry has been largely effected, in spite of diseases. Similar methods of treatment applied in the Philippines would similarly result in the re-establishment of the coffee industry.

Some of the most important resistant varieties are poor yielders with poor flavors, and weak in caffein—the active principle of the beverage. Some of them possess no stimulating qualities whatever. The species that is superior in the above-named qualities is *Coffea arabica*. If attention is given to preventing or curing the disease (*Hemileia vastatrix*), the re-establishment of the industry will soon come, as shown by work already accomplished elsewhere. Our present work here is strong additional evidence along the same line.

Previous Work on Spraying for Rust in Other Countries

P. J. S. Cramer (2) noted that the production of coffee in Java under the Dutch government had fallen from an average of 923,333 piculs (123,111,100 lbs.) in the five years from 1880-1885 to 81,746 piculs, in the two years from 1906-1908. This was due to *Hemileia vastatrix*. To check the disease, spraying with Bordeaux mixture and the search for resistant varieties were undertaken. Spraying with Bordeaux has given good results in the seed beds and nurseries, but in the plantations of Java it is not generally practiced.

A. L. Herrera (3) investigated the work of a disease of coffee due to *Stilbella flavida* in Oaxaca and in other parts of Mexico. In addition to this fungus other species were also studied. The application of Bordeaux mixture for the control of diseases of this sort was found to be effective.

Massee (4) says that *Hemileia vastatrix* had been reported as a serious fungus disease, occurring in various regions upon indigenous species of Coffea. He suggests Bordeaux mixture.

J. Buis (5) noted the ravages of *Hemileia vastatrix* on coffee in Ceylon, Madagascar, Réunion, and elsewhere. He studied various means of preventing the disease, such as the destruction of the affected foliage, spraying and fumigating the diseased plants, also the influence of location on the disease, resistant varieties, etc. He said, "Spraying was found to be very effective under certain conditions but it is often so expensive as not to be economically advantageous. Liberian coffee and some Java and other hybrids seem to be quite resistant so far as the author's investigations have been carried. Improved culture seems to be valuable in rendering the plants less liable to injury. When Arabian varieties are grown the planting should not be made in situations where there is too great humidity and heat."

Present Work

In connection with this work, there were planned and carried out duplicate experiments on native coffee (*Coffea arabica*) to try the effect of various treatments, such as spraying, pruning, and manuring on its production. These involved the handling of separate lots in different localities; one lot at Lipa and the other at Los Baños. Both of these received the same treatment. In each place 48 trees were selected for the experiment. This lot was divided into sets and each set received its own treatment; that is, no two sets received similar treatment. Out of 48 trees, 24 were used for fertilizer study, but these were still divided into sub-sets, each receiving different fertilizers; that is, six were given horse manure, six ash, six ash and horse manure, and the other six remained as checks. One-half of the total number of trees from each sub-set was sprayed and pruned. Twelve trees were used for a spraying experiment, and the other twelve for a pruning experiment, but one-half of the latter were sprayed also. For most

comprehensive conclusions, the number of trees is, of course, inadequate. Also the experiment should be duplicated not only in two sets of conditions, but in many. The present studies have been strictly limited by the time and expense involved.

Manuring

The manuring of coffee is as important as is that of any other culture. There are various modes of application, but many arguments are in favor of hole application. The reasons are well given by J. Ferguson's Notes on Manuring (6). They are as follows:

> "While of late years Ceylon has been making progress in the knowledge by which suitable fertilizing substances are scientifically selected, there are probably wide divergences of opinion, among practical planters, in respect to the best mode of applying them. Since the controversy was at the hottest in 1871, it has cropped up, from time to time, in the correspondence columns of the 'Observer'; without bringing forward anything novel or original. There is hardly any possible way of applying manure to the coffee plant, from tossing it under the bush and leaving it there, to depositing it in the bottom of a hole under two feet of soil, that has not found advocates, and whatever plan has been proposed, its advocate professes to be a student of Nature. 'Nature,' says one, 'never buries her fertilizers in holes, but drops them on the surface.' On this it may be remarked that when we have manufactured an artificial coffee bush we have thwarted and tortured Nature too much to pretend to follow herein any part of its treatment; we have made a condition of surface very different from that on which Nature feeds her wild vegetable children. Our manures are much more elaborately got up than Nature's and we can not afford to let them be baked by the sun, or washed by the rain. To the gentleman who tells us that Nature, having furnished the coffee plant with a deep tap root, intended that it should assist in collecting the food of the plant, and therefore should have manure placed in deep pits to encourage it to throw out feeding roots, I reply: I have never questioned Nature on this point, but I have observed that in all sizes of hole, in all kinds of soil, the coffee plant throws out its strongest lateral roots within 6 inches of the surface. . . . My object in applying fertilizer to my tree is, that I may at the earliest possible date obtain an equivalent value in coffee beans, together with a fair profit on the capital invested; I therefore put my manure where there are thousands of suckling mouths gasping for it, and where the surrounding influences will tend to hasten the complete decomposition on which its value depends. If, therefore, I am obliged to put my fertilizer in holes, I make them only nine inches deep, fill them with blended soil and manure, finished off with a surface covering of from one to two inches of well-broken earth."

In the present experiment, the manure was applied in holes of not less than two feet by one foot, and not exceeding one foot in depth, and at a distance of two feet from the stem of the tree. Before the fertilizer was thrown into the hole, it had been mixed very finely with the soil taken from it, so that the decomposition might take place very rapidly. Its application was made tri-monthly; that is, one hole for each tree for every three months, so that in one year the trees will be surrounded with a well-manured soil.

The dates of applications of manure are as follows:—At Lipa, first application, August 1, 1914; second application, November 7, 1914; third application, February 15, 1915. At Los Baños, first application, July 23, 1914; second application, October 30, 1914; third application, February 8, 1915.

Pruning

Pruning plays a very important part in the cultivation of coffee. It compels the coffee plant to maintain an ideal form.

Pruning can be classified into three groups (7): light, medium, and heavy. Each of these has its own advantages; that is, light pruning is recommended in places where soil and elevation are moderate. The resulting trees usually carry the greatest amount of foliage and bear the best crop. The blossom has an ample protection from the burning sun, and the tree is provided with a sufficient leaf surface. The medium pruning is recommended in places where the soils are rich, accompanied by a high stage of cultivation, and where

trees have had careful pruning from the first. The trees of this order generally have more primaries, and the bearing wood confined to the age of two years. Lastly comes the heavy pruning, which is very useful in bringing neglected trees into shape. The first pruning of this sort consists of the removal of all dead wood, which of course is to be burned afterwards. Then careful suckering is at once to be employed, with the understanding that the most healthy and vigorous suckers are to be left for the following year's crop. In the second handling more of the unnecessary branches and twigs may be removed; and finally by the third handling the trees may be brought into good shape. To insure full understanding on the subject the following may be quoted from "The Planter"(8):

> " 'To ensure a regular and strong tree, handling must be resorted to early. In doing so take off all the branches that are within six inches of the stem, and make an opening of one foot in circumference in the center of the tree. This, besides strengthening the primaries, will admit the sun and air, both of which are beneficial to the growth of the tree, as well as the ripening of crop. *Next run along the primaries and single* out the secondaries leaving no pairs, but one secondary only *at each joint, on either side of the primary alternately. This is thought very unnecessary by a large* class of planters, but if they will only study the tree itself, they will find that although Nature throws out the secondaries in pairs, almost invariably one is stronger than the other; and by a little care the strong ones can be left and the weak ones taken off. It is better to look to the strength of the wood than to the quantity of it. As secondaries left on too near the stem tend to weaken the primaries, so do they when left in pairs, cramping, as it were, that expansion which takes place under the treatment advised. To those who wish to leave everything on for the virgin crop, I would say that I have known coffee trained under the above system give a virgin crop of seven cwts. per acre.' This is a very good description of the whole process of pruning the tree; but the portion for which it is mainly quoted, and which fits in to the previous directions, is that part which is italicized. On this point, the late Mr. R. D. Gerard, who was a leading planter in his day, used to direct his superintendents *to leave not more than five secondaries on each primary*. That number he considered as many as the tree could safely carry, and sufficient to produce all the crop the shrub was thought capable of yielding. This, too, in experienced hands, was valuable advice. But, the superintendent who may have fifty or a hundred men engaged at one time in pruning a field can not possibly at the same time have his eye on every one of them, watching the cut of every knife. Thus, then, we have pruned an estate which was found in tolerable order. Let us suppose the case of one found in very bad order as regards pruning, with trees growing up as they liked, matted in the center, umbrella-topped, exuberant in suckers, abounding in dead wood, and that have not been pruned for years. Trees in such condition I would not attempt to reform all at once; because, if I did, I would have to cut off most of the bearing wood, in divestingthe trees of all that was unshapely, irregular, of the tree. And that would not pay—for by so doing I would get very little crop for two years. In such case I would begin with suckers, tearing out every one, so as to let me see the tree, and let the sun and air penetrate it. Then I would cut off all the dead branches back to where there was life, then I would clear everything within a span of the center. I would begin by training into shape the primaries. Supposing they have been cut back to parro sticks, or broken or deformed, I would cut back to the first eye that is sound and healthy, at the point where a secondary shot out. By making a slanting cut on the lower side of the primary, but without touching the secondary, the latter will soon accommodate itself in the position to take the place of the destroyed primary, or if a secondary, has sprung from the side of the primary, at right angles, and if a strong tertiary has sprung out from it, I would cut the secondary at the point of junction with the tertiary, leaving this latter to take the place of the primary. This, however, I would only do if the secondary has so grown that it can not be trained to follow the lead of the primary. I would then apply myself to secondaries and tertiaries, taking off such as could best be spared, and training those left as far as practicable into their original shape; for it is by a careful selection now of the old wood you have that the future tree is formed. Thus I would go on systematically reforming the tree; but instead of doing it at once, I would do it gradually over two or three years, even at the risk of offending some one who is an admirer of symmetry. By these means I would retain for the time a good deal of wood of irregular growth, which many planters would be disposed to call *horrid pruning*, but the wood so left would repay me for pocketing my pride and preserving my sticks; while I would repeat to my fastidious friends that it is my practice to *prefer crop to symmetry*. The tree would thus be trained into shape in course of time without involving too great an immediate sacrifice."

Spraying

It has been shown that the best means of combatting the attack of *Hemileia vastatrix* is the use of Bordeaux mixture. It may be applied by spraying. Trees should be treated thoroughly with it before the fungus commences to show its yearly sign of attack, which of course always comes soon after the rains start, about the beginning of July. The application may be bi-weekly, or less frequent.

Bordeaux mixture (9) for coffee should be made as follows:

Copper sulphate	3 lbs.
Calcium oxide	5 lbs.
Water	50 gallons.

Dissolve the copper sulphate in a wooden bucket—tin vessels should not be used. There are two ways of dissolving the copper sulphate; namely, by suspending the material in a few gallons of water, wrapped in a coarse sacking, from a stick, placed across the top edge of the bucket. It takes from eight to twelve hours to completely dissolve it. The other is by the use of hot water; that is, the copper sulphate should be placed at the bottom of the bucket, and then hot water in small amount is added. It takes only a few minutes to dissolve it in this way. Then the solution is diluted up to twenty-five gallons. Take five pounds of stone lime and slake it in a tin pail. A few pints of water are added until all the lime is slaked, taking care to add little water at first, so as to obtain a creamy paste. When this gets cold dilute it also up to twenty-five gallons. These can be mixed together by pouring one into the other, or a bucket-full of each can be poured simultaneously or alternately into a third holder. The milk of lime as well as Bordeaux mixture must be well strained before using. In this way, fifty gallons of Bordeaux mixture of good quality is prepared.

In making Bordeaux mixture, two points of primary importance are to be remembered. First, freshly-burnt lime should be used. Powdered air-slaked lime will not produce good Bordeaux mixture. Second, see that the two constituents are diluted with water in the proportions of the formula before being mixed together. If the two solutions are mixed together in concentrated form, the resulting mixture will be of inferior quality.

Freshly-made Bordeaux is very effective and economical in the long run, and is therefore strongly recommended. But when more than one day old, it must be stirred very thoroughly before using.

To insure a good Bordeaux mixture it is a good plan to test the first mixing. There are several ways of testing: First, by immersing an ordinary knife blade in the solution for one minute. If no effect is produced upon the blade, the solution may be used; otherwise, the solution is not safe. Second, put a small amount of 10% solution of ferrocyanide of potassium in a dish and drop into it a few drops of Bordeaux mixture. It is safe to use, if there is no change of color in the mixture; but is unsafe if a cloudy reddish brown discoloration occurs immediately in the mixture. An unsafe mixture can be made usable by adding more milk of lime until its acidity is neutralized.

The most essential factor in the success in spraying coffee with Bordeaux mixture is the nature of the spray. It must be very fine and misty, so as to deposit on the under surface of the leaves exceedingly minute drops, which when dry produce an almost uniform, very thin, bluish film or dust. It must be so intimately attached to the surface of the leaves that it is not readily washed away by rains.

Two requirements must be taken into consideration in order to produce

a very fine spray. First, a special type of nozzle must be employed. Second, sufficient pressure must be applied at the nozzle. If these can be fulfilled, the best results of spraying can be obtained.

Trees Used at Lipa

The trees used at Lipa were as nearly alike as possible. They differed slightly in shade condition, but were of the same age, and the soil conditions were almost identical. Before any treatment was undertaken, a record of beans produced by each tree had been taken. After treatment was begun, bi-weekly observations were carried on, pertaining mostly to the work of *Hemileia vastatrix* on each individual tree.

Fertilized Trees:—Six were given ash. Each application amounted to one kerosene-can-full per tree. Six were given horse manure, in the same amount. Six were given ash and horse manure. Each application amounted to one kerosene-can-full per tree of the mixture of ash and horse manure in the proportion of one to two respectively. Six remained as checks. One-half of each lot of these trees was pruned and sprayed. Up to the time of writing, no effect of the fertilizers can be observed.

Sprayed Trees:—Twelve in number. Spraying with Bordeaux mixture was the only treatment given.

Pruned Trees:—Twelve in number. Six were also sprayed. The pruning has had a moderate but unmistakable effect, in lessened infection by rust.

Until about the 15th of August, 1914, the unsprayed trees appeared to be in as good condition as the sprayed ones, that is, very slight infection was noted for each individual tree. On August 30, a contrast was observed, becoming more and more pronounced as time went on. At the close of the experiment, 28 sprayed trees appeared entirely free from *Hemileia* infection while the other two had 0.2% and 0.3% of their leaves infected. On the other hand, the unsprayed trees appeared badly infected, the least per cent being 66, and the loss in leaves varied from 50% to 100%. Some of these unsprayed trees were quite bare.

Trees Used at Los Baños

The trees used here were not uniform in all respects; they differed slightly in age and shade conditions. Soil conditions were uniform before the experiment was begun. A record of beans produced by each tree was kept. After the treatment began, bi-weekly observations were carried on, pertaining mostly to the effects of *Hemileia vastatrix* on the individual trees.

Fertilized Trees:—Six were given ash amounting to 20 liters per tree. Six were given horse manure amounting to about 20 liters per tree. Six were given ash and horse manure, amounting to about 20 liters per tree of the mixture of ash and horse manure in the proportion of one to two respectively. Six remained as checks. One-half of each lot of these trees was pruned and sprayed. The fertilizers have as yet shown no effect.

Sprayed Trees:—Twelve in number. Spraying was the only treatment given.

Pruned Trees:—Twelve in number. Besides pruning, six were sprayed also.

Up to September 23, 1914, the unsprayed trees appeared to be in as good a condition as the sprayed ones, both being free from rust. On October 4, a contrast was observed which became more and more marked as the experiment progressed. At the close of the experiment, final observations were made and as a result it was found that *the sprayed trees showed no sign of infection whatever*. On the other hand, the unsprayed trees appeared badly infected.

The affected leaves varied from 5% to 99%, some unsprayed trees being nearly bare.

Effect of Hemileia on Yield at Lipa

Four trees growing under similar conditions were used in carrying out this test. They were of the same age; the shade and soil were uniform, and all showed a luxuriant growth before the observation was commenced. Moreover, they had an equal number of bearing secondaries. All trees gave practically equal amounts of green beans. Two trees were pruned and sprayed and the others remaining untreated as checks. On November 8, 1914, the crops were harvested, fermented, cleaned, and sorted into sound berries and poor berries. After completely drying the sound berries, the weight of each lot was taken on February 4, 1915. The results are as follows:

Sound berries produced by 2 sprayed trees, 85 grams.

Sound berries produced by two unsprayed trees, 38 grams.

The results show that the sprayed trees produced 123.7% more than the unsprayed ones, or in other words spraying saved 47 grams. The sprayed trees at present bear abundant flower buds, while those that were not sprayed show nothing, except dry twigs and sucker growths.

Effect of Hemileia on Yield at Los Baños

In order to make a survey at Los Baños of the effect of the *Hemileia* on yield, four trees growing under the same conditions were selected. They were all of the same age; the shade, soil and locality were alike, and all showed a vigorous growth before the observation was begun. Moreover, they were of the same shape and size, and had practically an equal number of bearing secondaries. A record of beans produced by each tree was taken; all gave practically the same amount of green beans. Two of these trees were pruned and sprayed. The rest remained untreated as checks.

Sound berries produced by two sprayed trees, 86.8 grams.

Sound berries produced by two unsprayed trees, 11.5 grams.

Thus the increase in yield due to spraying is 75.3 grams; or in other words, the unsprayed trees produced 83% less berries than the sprayed ones.

For a most satisfactory conclusion, the number of trees used is inadequate. But in order to get a fair idea of the destruction done by *Hemileia*, the average loss due to its attack on coffee in Los Baños and in Lipa was taken. From the preceding figures, it appears that the average loss was 69%—a loss that can be almost entirely prevented by spraying.

The Cost of Spraying

The cost of spraying materials used, as given by the disbursing officer and cashier of the College of Agriculture, was as follows:

Copper sulphate.	1 kg.	₱0.384
Calcium oxide...	1 kg.	0.022

In each place thirty trees were sprayed every two weeks from July 18, 1914, to February 6, 1915, amounting to fourteen applications during the whole time. Bordeaux mixture, made on the 3-5-50 formula, was used.

It took two hours (time spent in preparing solution, excluded) for two men to give thorough spraying to thirty trees. Each application consumed 339 grams of copper sulphate and 567 grams of stone lime. Basing the calculation on a day's work, two men working ten hours a day could spray one hundred and fifty trees.

The expense therefore of each application per one hundred and fifty trees would be:

1.695 kg. copper sulphate @ ₱0.384...	₱0.65
2.835 kg. calcium oxide @ ₱0.022...	0.063
Two men @ ₱0.80 a day.....	1.60
TOTAL.....	₱2.313

Since one hundred and fifty trees required ₱2.31 in spraying per application, then for fourteen applications it would require 14 times ₱2.31, or ₱32.38.

The average increase in yield per tree due to spraying was found to be 30.5 grams, or 4.575 kg. per 150 trees.

With coffee selling at ₱0.94 per kilo, 4.575 kg. would have a value of ₱4.30. Subtracting this amount from the expense of spraying, it gives ₱28.08 as the immediate loss incurred in spraying 14 times.

This loss may appear at first sight to be a reason for considering the spraying unprofitable. However, the fact is that this conclusion is as unreasonable as it would be to count the preliminary expenses met in starting a coffee plantation as a loss. There are three reasons for this. In the first place, the sprayed trees end the year vigorous, while the unsprayed ones are weak. It is already evident that, as a result of *this* year's spraying, *next* year's crop from the sprayed trees will be a heavy one.

In the second place, the trees in both Lipa and Los Baños were not normally productive this year. If the rate of loss due to *Hemileia* infection be computed on a normally big yield, spraying will be shown to pay. Under normal conditions, each tree is said to yield an average of one and a half pounds of coffee berries per season; therefore 150 trees will produce 225 pounds or 1.6 piculs of berries. Since spraying can prevent loss, then the saving in yield of 150 trees is equal to 69% of 1.6 piculs or 1.104 piculs. Note that this figure, 69%, is calculated on the yield of sprayed trees; reckoned on the unsprayed trees, the increase due to spraying my trees was 389%. "The Lipa coffee [10] sells locally at the rate of ₱60.00 per picul." The berries saved in spraying, at the Lipa price, would bring ₱66.24. Deducting from ₱66.24 the expense of spraying (₱32.38 on this purely experimental basis), we get ₱33.86 as the calculated profit from spraying 14 times.

In the third place, there is little doubt that results can be accomplished by spraying one-half as many times in the same period, in which case the expense is cut in half. It has seemed to me that the first great step ahead in Philippine coffee culture is being able to say that complete protection from *Hemileia* (and doubtless from some other troubles at the same time) can be secured by the thorough use of Bordeaux mixture. The minimum number of applications and minimum amount of materials which will do the work, can only be determined by a more extended study.

The effect of fertilizers on coffee, as well as on other trees, is rarely apparent in the first year. To see what effect fertilizers may have on *Hemileia*, will take one or two years after the application, and possibly even longer. Up to the time of writing, the manured trees have been equally affected with the unmanured ones, as to the degree of infection.

In both Lipa and Los Baños, the pruned trees showed less *Hemileia* infection than the unpruned ones did. Taking the average infected leaves on both pruned and unpruned unsprayed trees, pruned trees had 68% of their leaves infected, while unpruned ones had 83%.

THE WRITER'S ASSOCIATION WITH THE PLANTERS AT LIPA

On November 23, 1914, Mr. Rufino Marave and the writer visited his

plantation at Suluc, a barrio of Lipa, located at the foot of Mount Malarayat. His plantation is of about four hectares. The trees were in fruit, and his laborers were just beginning to harvest the beans. We walked around the plantation, making a thorough examination of diseased trees. We were unable to find a single tree free from *Hemileia*, but, on the contrary, all showed severe infection. Many trees were bare, and the beans on these trees had dried up before they reached the stage of maturity. Upon calculation, we found one-half of the total yield to be poor beans, which of course were worthless. Mr. Marave said that though his trees had been invaded by *Hemileia* every year, he used to get 20 piculs of coffee berries every two years. That is, his trees produce once every two years. Mr. Marave had not believed in the *Hemileia* as the cause of much injury. He had been of the opinion that diseases of roots and branches were the ones most destructive; but throughout the plantation we found very few trees which had died of such diseases. The search caused Mr. Marave to change his opinion, and he now believes that *Hemileia* is the disease that is responsible for the destruction of his plantation.

During the course of the experiment at Lipa, several planters examined these experiments. Due to the effect of Bordeaux mixture on *Hemileia*, which they saw, they appreciated the present work, and now believe that the re-establishment of the industry, if the old stock is used, depends upon Bordeaux mixture.

Conclusions

Among the diseases which attack the coffee plant in the Lipa and Los Baños districts, *Hemileia vastatrix* is clearly the most destructive.

Re-establishment of the industry could soon be carried out, if proper attention were given to it by the people. The Philippines present perfect natural conditions for growing this crop.

The previous work on spraying for *Hemileia* in other countries shows that Bordeaux mixture makes a perfect protection against its attack. The present work presents additional evidence to confirm these previous results.

Spraying has its best results when begun before the tree begins to show any sign of infection.

Hemileia infection is much less virulent in Los Baños than in Lipa; moreover, the infection begins earlier in Lipa than in Los Baños.

Spraying prevented loss to the extent of 69% of the possible crop, in our experiments.

Pruning lessens the degree of *Hemileia* infection.

The writer desires to express his thanks to Professor Charles F. Baker for his valuable suggestions and criticism throughout the course of this work.

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Cacao And Its Local Diseases

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Thesis presented for graduation from the College of Agriculture, No. 39

The present work has for its purpose a study of the conditions of cacao culture in the Philippines, particularly in the region about the College of Agriculture. Nearly every island in the Archipelago has more or less ideal natural places for the cultivation of this crop; yet the Philippines, in spite of admirable conditions for producing cacao, import a large amount annually. In 1912 and 1913, the Insular Collector of Customs ([1]) in his annual report for the fiscal year ending June 30, 1913, reported importations of 982,937 kilos and 779,081 kilos, respectively, with values of $308,191 and $235,507. Further, he reported for the same years importations of 21,370 kilos and 35,352 kilos of prepared or manufactured cacao valued at $10,628 and $17,474, respectively.

De Candolle ([2]), referring to the introduction of cacao into these Islands, says: "The Spaniards carried the cacao from Acapulco to the Philippine Islands in 1674 and 1680, where it succeeded wonderfully." Hart ([3]) emphasizes the importance of a suitable climate as a factor in the successful growing of cacao, and this vitally important requirement being possessed by Trinidad, he chiefly attributes its recognized high place as a cacao-producing country to this. He further states that "all countries having similar meteorological conditions will also be suitable for the cultivation of cacao, provided the soil conditions are favorable, and the lands are well protected from wind storms." These meteorological conditions are as follows: mean annual temperature, 78.5° F. (25.8° C.); mean annual relative humidity, 79.0 (saturation = 100); annual rainfall, 66.6 in. (1681 mm.). Macmillan ([4]) states that the cacao tree thrives best in a warm, moist climate at elevations of 150 to 450 meters, but also yields good crops in a moderately dry climate, provided the annual rainfall is not below 1525 mm. As indicated by Lyon ([5]), the Philippines are fully up to these primary requirements, not only along the eastern shores of the Archipelago, where the highest relative humidity exists and where the rainfall is more uniformly distributed through the whole year than upon the west, but also in places such as the narrow peninsula of Zamboanga where the recorded mean annual rainfall is only 888 mm., and yet cacao (unirrigated) exhibits a good and thrifty growth.

Simmonds ([6]) mentions Cebu and Negros as having paid a little more attention to the cultivation of cacao than other parts of the Islands, not enough, however, to supply the wants of the people even there, the deficiency being met by importations from Ternate and Mindanao. He further mentions the best cacao of the Philippines as having been produced in the small island of Maripipi, which lies to the northwest of Leyte, but the cultures there have long since disappeared. The 1903 Census ([7]) reports the area planted with cacao throughout the Philippines as 3,521 hectares with a crop of 689,249 liters, or an average of about 196 liters to the hectare, which is an exceedingly low rate of yield. As a matter of calculation, taking the above area supposedly planted to cacao trees, and with the then prevailing distances of planting, often closer than 2.4 meters each way, which in the quincunx arrangement would mean 1,336 trees to the hectare, approximately the total number of cacao trees occupying that

area should have been 4,350,000, in round numbers. With so many cacao trees in the Philippines and allowing each tree to produce (supposing all to have been bearing) at a modest rate of 30 pods each, giving a whole weight of 1.0 kilo per tree on the basis of 28 beans per pod, each bean to weigh 1.28 grams, and subtracting 50%, or at San Antonio, Los Baños, 55.43% of that weight for the loss occasioned by pests and fungus diseases, the Islands ought to have been producing annually some 2,000 tons of beans, or about 1/120 of the total world's production as reported in 1914 (8), which was 230,000 tons, with a value, in bulk, of ₱150,000,000.

The cacao tree has a long tap-root, and consequently requires deep and well-drained soil. In regard to the land most appropriate for the cultivation of this tree Hart (3) says: "An ideal spot on which to found a cacao plantation is a well-sheltered vale, protected by mountain spurs from the prevailing winds, well-watered, and yet well-drained, with a good depth of alluvial soil on which rests a thick deposit of decayed vegetable matter, easy of access, and in a district distant from lagoons or marshes for the sake of the proprietor's health. Such a spot in a climate similar to Trinidad could not fail to produce regular crops of the finest quality of cacao." Authorities on the subject who know the natural fertility of the Philippines as well as their general topography, particularly those rich and fertile spots such as the mountain slopes and valleys, watered with abundant rains and perpetual streams, regard this Oriental group as a natural cacao-growing region.

With reference to soil or location Fauchère (11) says: "Upon reading the chapter on soil in a treatise on the culture of cacao, one is often a little dismayed and apt to question whether all the conditions enumerated could be found in several countries put together." But this authority, in the light of actual field observations, states that the cacao tree is not so hard to suit as has been supposed, for it is able, like all plants, to adapt itself somewhat to the environment in which it is placed. "It grows vigorously in the alluvial clay of Dutch Guiana, in the silicious clay of Trinidad, in the volcanic rock of Guadalupe, and it gives a product of the best quality in the alluvial soil of the Venezuelan coast, which is composed partly of earth washed down by streams from the granite and gneiss formations. In these soils resulting from the decomposition of primitive rocks the cacao seems to improve much in quality, and the Venezuelan cacaos are renowned; those of Ceylon are likewise favorably known, and I am informed from a reliable source that those of Madagascar are considered worthy to be classed with the best."

The coffee industry in these Islands was almost completely annihilated by coffee rust in 1889, reducing some of the owners from "utmost luxury to complete misery." The cacao industry, on the other hand, has never yet seen an extensive development in the Philippines. It was brought here two and a half centuries ago and its cultivation spread very gradually. In 1903 (7) its area was nearly four times that of coffee, but the yield per hectare was very low, being only about one-half the rate formerly obtained in Cebu. The fact that the Islands have been importing cacao in ever increasing quantity, year after year, for many years, is evidence that they do not produce it on a commercial scale. In truth, the industry is now almost totally ruined. We can attribute this backwardness of the industry to three great causes, viz., fungus diseases, insect pests, and unscientific or

poor treatment of the trees in the field. With the exception of the researches of Banks (9) conducted in Negros in 1903, on the life histories of the insect enemies of cacao, no systematic study has been conducted in the Islands to ascertain what fungus diseases or insect pests are doing the most destructive work on these trees and the unchecked ravages of which are so profoundly affecting the yield throughout the Islands. In fact, so seriously is the yield affected that at present the industry has very rightly been spoken of by Nieva(10) as "almost dead."

Of pests and diseases there are a few only that seem to be doing active depredatory work. Among them are *Lasiodiplodia*, several species of *Nectria*, the cicadas, the mealy bugs, *Helopeltis*, and the borer beetles. On young plants, scale insects, aphis, leaf-eating beetles, and ants have some share in the depredations.

Of the fungus diseases which attack the cacao tree, some are purely local, while others such as the die-back and brown-pod disease, *Thyridaria tarda* (here known only in the *Lasiodiplodia* or *Diplodia* form), are almost ubiquitous in every country where the tree is cultivated (14). The fungus diseases usually found in a cacao plantation, and which are chiefly responsible for the loss in production, are probably due to the presence of the following fungi: *Lasiodiplodia*, *Phytophthora omnivora*,* *Nectria Bainii*, and *Nectria theobromae*.

Lasiodiplodia, according to Johnson, infects the fruits, stems and branches, and it is considered possible that the roots are also infected by it. "The mycelium of the fungus spreads through the tissues of the fruit-wall and then attacks the mucilaginous envelope of the beans and eventually the beans themselves. Infected fruits of Dominica and Grenada present a scabby appearance; small, blackish, corky patches being produced on the surface. Such fruits do not properly develop, and they do not usually decay, but the beans are frequently smaller than those of healthy fruits." Manuring and high cultivation have given beneficial results in the case of cacao trees affected with this fungus in the Dominican Republic. Should its attacks be serious, causing the branches to die back, lopping off and burning them, tarring the ends of the stumps, and spraying the pruned trees with a 3% solution of copper sulphate are recommended.

Phytophthora omnivora De Bary, the black rot of cacao-pods, has recently become very destructive to the cacao pods in Trinidad. According to Bancroft (12), in addition to its occurrence in the West Indies the fungus is also known as a parasite on the cacao plant in Ceylon, Sao Thomé, Samoa, Java, the Philippines, the Cameroons, and tropical America. "When a pod is attacked the shell darkens first at one end, the darkening then spreading over its entire surface. The mycelium permeates and destroys the entire substance of the pericarp of the fruit and often attacks the seeds as well. Attacked fruits are usually rendered valueless." All diseased pods should be removed from the tree together with any pods which may have fallen, and husks or shells which may be lying about should all be burnt. Spraying with Bordeaux mixture has given very good results in Ceylon. Careful and thorough pruning is also recommended to control this disease; it insures good access of light and air to the lower parts of the plant, and thereby lessens those conditions of dampness

* This very dangerous parasite, unknown locally when this paper was written, is now reported by Professor Baker as locally abundant. —E. B. C.

and darkness which are especially favorable to the development of the fungus.

Nectria Bainii (Cacao pod blotch), as described by Massee (13), causes semi-circular dark blotches on the pods, the diseased portions becoming soft and watery. At a later stage the blotches become covered with a velvety interwoven layer of yellowish, rust-colored, or orange mycelium, which is studded over with the minute, orange-red perithecia. To check the spread of this disease Stockdale (14) advocates collecting all diseased pods and burying them, together with all husks and shells, with lime in trenches or pits. Burning the diseased pods with all husks and shells is economical.

Nectria Theobromae (canker of cacao) as described by Bancroft is recognized by the production of a red, gummy liquid which oozes out from the bark of the trees. If the bark be cut off, the inner tissues are found to be red in color, the discoloration extending as far inward as the young wood. An excision of the cankered part, removing a little more than the affected area, with a sharp knife, and careful sealing of all wounds with tar and clay in the form of a thick paste are advantageous in checking the spread of the disease.

According to Bancroft (12) *Thyridaria tarda* (as to its *Diplodia* form) was described by Hennings in 1896 on the wood of cacao from the Cameroons. It has since been shown to occur in tropical America (including the West Indies), Java, Samoa, Ceylon, the Philippines, and Sao Thomé. The fungus attacks the stem and fruits. On the former it is popularly known as "die-back," and on the latter as "brown-pods." Its first appearance is in the form of a discoloration at one or other end of the fruit. "The discolored area extends until the whole, or nearly the whole surface of the pod becomes dark brown in color. The fungus spreads through the tissues of the 'shell' to the mucilaginous coat surrounding the beans and finally attacks the beans themselves. The fungus can only effect an entrance into the stem through a wound; in the case of the fruit, however, it appears to be capable of entering through the wounded basal or stigmatic ends. All wounds made on the stem by pruning, or such as have arisen from other causes, should be sealed with coal-tar or with a mixture of coal-tar and clay. An experiment conducted in the La Perle estate, Sta. Lucia, has shown that this disease may be defeated by high cultivation, manuring, and attention to careful pruning."

The fungus diseases which are positively known to infect the pods, stems, and branches of the cacao tree in the region of Los Baños are *Lasiodiplodia Theobromae*, *Ophionectria Theobromae*, and *Aspergillus Delacroixii*. However, the extent of damage caused by these fungus diseases to the cacao industry throughout the Islands, just as that caused by insects, is not known. There is a great need for a thorough survey of these diseases in the Islands.

Varieties of Cacao

The Criollo and Forastero cacaos are the only varieties grown here now. Certain of the Criollo types are universally accepted as being incomparably the finest varieties in general use. There are three or four recognized forms, such as the Venezuelan, Nicaraguan and Trinidad, and they are characterized by a long, thin-shelled, pointed pod, usually with more or less of a constriction near the base. This constriction or "bottle-neck" shape near the base is not constant. "The ridges, or angles, are usually more pronounced and sharper than in the case of the Forastero. The typical Criollo seed is pale-yellowish white or pinkish yellow." The

ripe pod is usually of a yellow color but may in some forms take on a reddish or pale-purplish tinge, especially upon the crests of the ridges. Criollo, in aroma and flavor of the cured seed, is excelled only by Pentagona (8), a subordinate variety well known in tropical America and considered by Hart to be the very best in the world as to flavor.

As to Forastero, Barrett (8) says: "This is by far the commonest variety of cacao throughout the world. In its many forms it constitutes probably 80% of the total output. The pod is characterized by a certain smooth appearance, and a more or less cylindrical shape, usually with an abruptly tapering point and a square base. The color is almost always purple or dark red, with just a tinge of yellow at maturity between the ridges. The seed is of good size, purple, or at least pinkish, and, in some forms, of almost as good quality as the Criollo, while the productiveness is unquestionably better. The seed is usually somewhat flatter than that of the Criollo type."

Lyon (5) in comparing the merits and demerits of Criollo and its final product with those of Forastero and Calabacillo says: "On the other hand, in point of yield, vigor, freedom from disease, and compatibility to environment it (the Criollo) is not to be compared with the others. Nevertheless, where such perfect conditions exist as are found in parts of Mindanao, I do not hesitate to urge the planting of Criollo. Elsewhere, or wherever the plantation is tentative or the conditions not very well known to the planter, the Forastero is to be recommended." Lock (15) says: "In choosing seed, a good Forastero strain should be selected as being more prolific and less susceptible to the attacks of canker and *Helopeltis* than the old Ceylon Red or Caracas variety (referring to one of the Criollos)." A passage by Hart (3) advocating the same thing is illuminating: "Whatever the kind was that was cultivated and reported to have succumbed to disease in 1727 (a blight attacking the pods under certain atmospheric influences), it is fairly evident that it was more susceptible to disease than the later-introduced 'Forastero,' and, in consequence, was less planted in subsequent years. The Trinidad 'Criollo' is still much less vigorous than 'Forastero,' which tends to show that this (the Criollo) was the kind so badly affected by diseases one hundred and eighty-two years ago."

From the above recommendations we can conclude with safety that the Forastero type and the best of its forms are fitted to supplant all other types which tend to be unpromising, unproductive, weakling, non-vigorous, deformed and susceptible to diseases.

Factors in Cultivation

For the permanent success of a cacao estate the following factors, according to Smith (16), must be observed: "(1) Irrigate with good water; drain, aerate, and cultivate adequately; (2) Manure regularly to replace rather more than you remove; (3) Act with discretion, caution, and moderation."

As has been previously said, lack of care, and the accompanying unchecked ravages of the fungus diseases and insect pests, have caused the depression of the cacao industry here in the Islands, just as occurred with coffee; although in the case of the latter it was quick work, while in the former case the detrimental effect has been very gradual, for which reason it never forcibly intruded itself on public attention.

No less important factors, in the culture of cacao, are judicious pruning and general sanitation, including timely spraying with Bordeaux and perhaps

other spraying mixtures. It is decidedly necessary to use only the sharpest knives in harvesting the pods. Treating the wounds from pruning with such substances as coal-tar or ordinary white paint is an excellent practice and should not be overlooked.

Plan of Experiments

The present work has been planned with the object of finding out the actual conditions of the cacao trees in the region around Los Baños, Laguna Province with respect to the care and attention that they receive from the owner and to determine his actual profit. An attempt has also been made to study the reaction of the tree to better care. The cacao trees observed in this region vary in age from five to fourteen or fifteen years.

These trees have been examined as to:

1. Size of tree and shape.
2. Number of heavy main branches.
3. Presence of dead twigs and branches.
4. Number of healthy pods.
5. Average size of pods.
6. Number of dead and mummified pods which are fungus-infected.

These observations began in February, 1914, and continued until the latter part of May following, requiring altogether about four months, the best fruiting season of the year. For a beginning, to become familiar with the local trees, one hundred individuals were carefully examined and measured. The table of statistics compiled from this study shows the following maxima, minima and averages:—

From the preceding figures we see that an uncared-for native cacao tree produces an average of 17.72 good pods in a season, the loss being 22.04 pods or 55.43% of its evidently possible bearing capacity. In the experiments where trees were sprayed with Bordeaux mixture an average of 27.4 good pods from each tree has been realized which at the current local price of 10 centavos per 100 beans, would amount to ₱1,137.15 to the hectare as against ₱735.36 from the untreated trees, a difference of ₱401.79.

In connection with the above observations made at San Antonio early in February, 1914, all the cacao pods exhibited in the Bureau of Agriculture booth in the Exposition in Manila in that year, numbering 151, were also examined and their measurements taken.

The average length of all these pods was 15.5 cm. and the average diameter, 7.06 cm. Included in the 151 were seven which received first prize for "Mulatung Pula," with average sizes of 18.33 by 7.82 cm.; and seven which received first prize for "Mulatung Puti," 18.52 by 7.95 cm. Both of these lots came from Silang, Cavite. Other Silang pods were below the average size.

One hundred pods were cut open and their seeds counted to determine the average number of beans in an ordinary cacao pod. Ninety-four pods were furnished by San Antonio trees, four were from Calauang brought to the College of Agriculture by Mr. Elayda, and the last two pods were furnished by the exhibits in the Exposition already referred to above and belonging to two varieties, "Mulatung Puti" (white) and

	Height of tree cm.	*Diameter of trunk cm.*	*No. of main branches*	*No. of dead twigs and branches*	*No. of healthy pods*	*Average size of pods in cm.*		*No. of dead and mummified pods*
						Length	*Diameter*	
Average	378.29	8.88	3.34	2.93	17.72	14.206	6.689	22.04
Maximum	560.00	—	—	—	77.00	17.6	7.8	126.00
Minimum	200.00	—	—	—	1.00	12.0	5.7	0.00

"Mulatung Pula" (red), both grown at Silang, Cavite. The average number of seed found was 28.11; the minimum was 17 and the maximum 40.

Likewise for the purpose of obtaining a more or less accurate figure in regard to the average weight of sun-dried cacao beans (dried for a week and ready to market), a sample was obtained from an owner of a few dozen trees at San Antonio. Five hundred fifty-eight beans were found to weigh 715 grams, the average being 1.28 gram.

Experiments in Manuring, Pruning, and Spraying

The experiments described below, except the last, were commenced on August 1st, 1914, and covered manuring, pruning, and spraying with Bordeaux mixture.

The piece of ground on which the experiment was conducted contained some 84 trees of varying conditions of health, from good to bad. They were from 10 to 11 years old, and were planted at an average distance of 2×2.5 meters. They were typical native trees in that no attempt had ever been made to cultivate or care for them. The stems, branches, twigs, and suckers were simply left to take care of themselves, in consequence of which many of the branches and twigs and even main stems were actually dead, but those which had survived were growing fairly well, a sight not at all uncommon in any cacao growing region in the Philippines. The cacao trees are not heavily shaded, although in some parts a few large trees, *Anona*, *Citrus*, *Areca*, tamarind, santol (*Sandoricum indicum*), chico (*Achras Sapota*), and buri (*Corypha elata*, Roxb.) are irregularly intermixed with them. They are sheltered from the full force of the southwestern winds by patches of young coconut trees. As to the soil in which they have been planted, it is not ideal, being a too heavy, tenacious, clayey loam.

For experiment, trees were chosen as uniform as possible in size and condition, and also as uniform as possible in shade conditions.

The plan of the experiment was as follows:

I. For fertilizer study there were selected 12 cacao trees—

Three without fertilizer—check.

Three with manure:—1 petroleum can each.

Three with ashes:—1 petroleum can each.

Three with manure and ashes:—1 petroleum can of manure plus one-quarter can of ash.

II. For pruning there were selected 15 trees—3 reserved for check.

III. For spraying with Bordeaux mixture there were selected 12 trees to be continuously sprayed bi-weekly, and 3 for check.

For applying the manure, a hole for each of 9 trees was dug at the convenient distance of 90 cm. from the center of the trunk, the hole having the dimensions: 60 cm. long, 30 cm. wide, and 30 cm. deep. All were dug three days previous to refilling, with the soil thoroughly mixed with manure in order that they might be well aerated. The manure referred to was well-rotted horse manure, obtained from the stables in the vicinity. The first application of manure was August 1st, 1914, the second took place October 31st, after an interval of 3 months, with the holes for it opposite to the ones previously dug and at the same distance from the trees as the first ones; the third application took place January 30th, 1915, with the holes located at right angles with the last ones.

For the pruning operations carried out in this experiment there was no explicit rule adopted as to the regularity in the cutting off of the branches

or twigs from the main stem, since the trees differ widely in habit. In the pruning, Hart's advice was kept in mind that:

"It should be a rule when pruning that too many branches should not be removed at once. It is a mistake to prune heavily at any one time, as it gives the trees too great a check, and causes too great a disturbance of the growth . . . In pruning neglected trees, the first thing to be done is to cut out useless wood, or wood which can never be expected to bear or to produce bearing branches, or wood that is diseased or cankered. The next thing is to equalize or balance the trees, and the last, to thin out the branches and foreshorten them where required . . . In removing branches the greatest care should be exercised not to make jagged, ragged, splintering or slivering cuts, but to make clean and even cuts close to the wood and near to a bud or young branch into which the sap will be presently directed if the operation is well performed . . . It is taken as an accepted rule that in established cacao, pruning or 'trimming,' as it is called in Trinidad, is best carried on at the close of 'crop time.' The conclusion is a reasonable one as the trees are then devoid of both flowers and fruit, and at this period there is less possibility of injury."

Trees for spraying having been selected, the first application of the solution, of 0.72 kg. copper sulphate and 1.56 kg. common lime, in 100 liters of water, took place August 8. It was planned to make applications once every two weeks. There were two instances in the first two months when the program was not followed on account of excessive rains. This made the interval in these cases one week longer.

Preparation of Bordeaux Mixture

For the sake of convenience stock solutions of the two chemicals, copper sulphate and common lime, are prepared; the former can be well deposited in a demijohn and the latter in an ordinary petroleum can. Taking the copper sulphate first it can be quickly dissolved for the stock solution in boiling water, especially if it has been more or less uniformly pulverized already. For this the volume of the stock solution can either be 10 liters or any convenient fraction. In order to be able to secure a perfectly homogeneous stock solution during the stages of dissolving the chemical, the demijohn must be constantly shaken. The lime is then stirred vigorously in the can, adding water gradually up to the same number of liters given the copper sulphate, stirring to be continued till the lime is thoroughly converted into a milk-like solution. The final solution for spraying, of say 10 liters, is made by taking one liter of the thoroughly well-shaken solution of the copper sulphate stock solution and mixing with one liter of equally well-shaken lime stock solution, and diluting the mixture to 10 liters. A good solution should have a neutral or slightly alkaline reaction and a clear sky-blue color. To be most effective it should be applied as soon as the solution is prepared and thoroughly mixed. Care should be exercised in straining the lime to be used for this purpose. It is advisable that the solution be slightly alkaline, because if copper sulphate be in excess, it has an acid reaction, and scorching of the foliage may follow. To test the solution, litmus paper is used. Another practical test for the acidity of the solution is by putting the clean blade of a steel knife into it; if, after a few minutes, the blade shows a somewhat reddish-brown tinge, the solution is acid, otherwise the blade remains clean and bright. The solution being so prepared, it is ready for application.

Result of the Experiment

During the last days of July, 1914, all the trees in the entire block under observation were flowering. It was especially desired to determine the influence of spraying on the setting of fruit. There were in all 42 trees under observation and the record of the production of one set is given in Table I.

TABLE I.

Spraying of Cacao with Bordeaux Mixture and Resultant Pod Production.

Sprayed Tree No.	Aug. 16		Aug. 23		Oct. 10		Oct. 24		Nov. 7		Nov. 14		Dec. 12		Jan. 9-16		Jan. 30		Total		Average	
	Good	Bad	Good	Bad	Good	Bad	Good	Bad	Good	Bad	Good	Bad	Good	Bad	Good	Bad	Good	Bad	Good	Bad	Good	Bad	Good	Bad
S— 1			1		9		23	1	31		31		18	13	11		9	9	9	23	329	420	27.4	35.
S— 2					13				80		105		126	5	97	39	67	20	67	64				
S— 3	2				12						55		69	4	62	9	48	12	48	25				
S— 4	1				4	1					10		10		12		12	2	12	3				
S— 5					6	4					25		23	8	21	4	19	8	19	24				
S— 6			2		10	6					25		33	4	32	6	32	2	32	18				
S— 7					3						3		16	2	17		16	13	16	15				
S— 8	6		8		50	4	85	1	118		129		50	59	52	27	42		42	91				
S— 9											16		28	9	29		23	5	23	14				
S—10	2				35	4					29	6	20	10	17		12	10	12	30				
S—11	3				18	3					21		19	5	15	7	12	6	12	21				
S—12	8				68	2	92	1	111		103		55	56	45	33	37		37	92				
Check No. 1													9	1			10		10	1				
" " 2													27	10		14	2	11	2	35				
" " 3													9	7		12	2	4	2	23	14	59	4.6	19.6

Pods which succumbed to *Lasiodiplodia*, etc., sprayed, 56.0 %

Pods which succumbed to *Lasiodiplodia*, etc., unsprayed, 81.0 %

Pods which succumbed to *Lasiodiplodia*, etc., average of all control trees, 92.2 %

Tree No. 4, before spraying, had less than 10 leaves; now it has a great many healthy ones.

In the tables prepared from the field work, the most definite results are apparent as a result of spraying with Bordeaux mixture. In pruned and unsprayed trees, 76% of the pods were destroyed, and on manured but unsprayed trees, 71.4%. The full tables showing these results are omitted here. Final results from pruning and manuring will not be apparent for several years. Manurial experiments on cacao trees carried out in the West Indies ([19]), show that the first observation should be made at least one, two, or even three years after the application; that is, the trees do not respond fully to the fertilizers applied to them in less time than that.

Of the 12 trees sprayed in my experiment an average of 27.4 good pods to each tree has been realized as against an average of 17.72 good pods observed on one hundred untreated native cacao trees. According to these data, allowing 1,480 trees to the hectare, in which case the trees would be far better spaced than in ordinary native practice, a hectare of treated trees will give 1,434.68 kilos, which, at ₱0.60 per kilo, would amount to ₱860.80, as against ₱541.98 in the case of untreated trees, thus giving a gross profit of ₱318.82 per hectare for the use of Bordeaux mixture. In this experiment the combined cost of chemicals and labor per application per tree amounted to ₱0.04. The mixture need be applied only three times during the season, which is sufficient when done thoroughly and at the correct time. This would make the cost per hectare, ₱177.60. Rorer, who has carried out the same experiment in Trinidad ([17]), on a more extensive scale, and who has reported encouraging results, recommends spraying four times in a year. He further recommends that the application be made when the trees are well covered with young fruit, but not when in full bloom. Other spraying experiments, aimed to control insects at the same time by adding 1.8 kilos (4 lbs.) of arsenate of lead to every 189.25 liters (50 gallons) of Bordeaux mixture, are reported in the publications of the Department of Agriculture, Trinidad and Tabago ([18]), and the Bulletin of the Bureau of Agricultural Intelligence and Plant Diseases.

In our experiments it is gratifying to note that all pods harvested from the trees which have been sprayed with the Bordeaux mixture are practically free from the attacks of fungi, these being found on very few pods on 3 trees, and then to a much less degree than on unsprayed trees, the majority of which in the whole block are seriously affected. Sprayed tree No. 12 and the control tree No. 2, standing side by side with an intervening distance of about 2 meters, showed the former practically free from black spots, all the pods being yellowish-red and healthy, while in the latter all except 2 of its thirteen pods were badly affected with black rot and their sides were cracking. The trunks, stems, branches and leaves of the sprayed trees were likewise free from fungi and insects, and were far more healthy in appearance than any of the unsprayed trees in the entire block.

Individual observations of other trees at San Antonio have shown that even utterly-neglected trees were able to bear pods ranging from 60 to 130 in number, but the great majority of them, and very often 100%, were dead and black, and with large cracks showing that they were victims of fungi and insects. In contrast to these, the ones which were observed to have received some care in the way of keeping the ground around the base free from grasses and weeds, even though the soil was very hard, were found to give as high as 70 or 90 good pods. The trees in question have already reached matur-

ity, being from 10 to 15, or probably more, years of age. The younger ones, those from 5 to 6 or 7 years old, have been observed to be least affected with either fungi or insect enemies. In general they appeared more healthy, thrifty, and neat than the older ones, and bore a much higher percentage of good pods. The best of these promising young trees was one six years old which bore 97 pods when it was visited, and the owner said that he had already harvested 10, thus making its bearing record 107.

Conclusions

To prevent or check the ravages of fungous and insect enemies of the cacao, spraying with Bordeaux mixture has proven very satisfactory. It should be done thoroughly and at the proper time, with an efficient apparatus.

The combatting of the enemies of cacao is a matter of great enough economic importance to be worthy the most serious attention of all owners of large or small plantations.

Dead or dying pods, leaves, or branches, should be removed from the trees with a sharp knife, and burnt.

Trees should be fertilized, giving them a little more plant food than is taken from them in the crop. For this purpose utilize first the natural manures available everywhere. Some authorities advocate "surface manuring" for the reason that the great majority of the feeding roots are near to the surface of the soil. We have practiced only sub-fertilization.

Prune or trim the trees to ideal form. This training should be given them in the earliest years. An ideal tree should not have more than three main stems. The height should here be limited to not more than 2.5 or 3.5 meters.

General sanitation in a plantation, including all such measures as are mentioned above, will pay.

Recommendations

For planting, use only seed from best and most resistant trees.

For the best development of the trees they should be planted between 3.6 and 4.5 meters apart each way, depending upon the variety and the soil.

Better and more uniform methods of fermentation or "sweating" beans are needed in the Philippines to improve the "break" of the beans, keeping quality, aroma, and color.

Simple forms of machine washers and dryers should be thoroughly tried out in the Philippine Islands.

Acknowledgments are due Professor Baker for constant suggestion and advice.

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Preliminary Results of Experiments in Hog Feeding at the College of Agriculture

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Comprehensive and carefully-planned experimental work in animal industry has never yet been undertaken in the Philippine Islands. This is very remarkable for several reasons. The assets and interests of the Islands are almost purely agricultural and for this reason animal industry must inevitably play a most highly important and fundamental part in the development of the Islands. There can be no more important subjects in Philippine Agriculture than the improvement of our stock and methods in hog feeding and breeding, than the improvement of methods and stock in carabao breeding and feeding, than the improvement of our poultry and of the Filipino pony. Along none of these lines has anything even approaching comprehensive or well planned work yet been undertaken. It is perhaps needless to say that a vast amount of experimental work, including comprehensive tests and trials under varying conditions, must of simple necessity precede safe or sound extension or instructional work of any nature whatsoever. Our present lack of exact and well-founded knowledge in any of these matters will mean simply that any recommendation we might make to farmers or anything that we might teach to advanced students in agriculture would be in the nature of "glittering generalities" that might be locally applicable or as likely not, and which, in any case, would lead the farmer into what would be, to all intents and purposes, purely experimental work of doubtful outcome.

At the College of Agriculture, advanced courses are supposed to be given in animal industry, in which not only the fundamental general principles are supposed to be taught, but far more important than this, their exact application to Philippine conditions is supposed to be fully developed. Without an experimental station in the Philippines where such work has been or could be in progress, it has been absolutely essential that the College proceed as rapidly as possible to obtain the necessary data by experimental work of its own. Without funds for the purchase of stock or other highly necessary facilities, the difficulties that have stood in the way of the successful pursuance of this work have been enormous. However, such scant facilities as have been available during the first years after the foundation of the College have been used to the uttermost limit of their possibilities. Full detailed and comprehensive plans were elaborated first of all, for adequate experimental work in the feeding and breeding of hogs. Such stock as could possibly be obtained was used to put portions of this work under way and some important results have already been obtained along both of these lines. Comprehensive studies of the Filipino pony, of the vaca, and of the carabao were begun at once in order to furnish the proper basis for any future work in the development of these three important animals. In the case of the Philippine pony very extensive data were gathered relating to the type characters and physical condition of the pony stock as it now exists in these Islands. The elaborated results from this work were submitted to a considerable number of the most prominent horse breeders of the world, and their detailed opinions and recommendations covering the improvement of this stock were obtained. This gave us a large amount of the

most highly valuable professional advice that the world can afford, and without cost to the Islands. It was a matter of great gratification to us that the general character of the conclusions and recommendations of breeders abroad coincided in all important points with the conclusions that we had formed here after several years of careful study on the ground. Among recommendations which we have made was that the pony stock should be improved by the introduction here of the most highly-developed pony breeds that the world could afford. A request from the College for the importation of a Welsh pony stallion was acted upon favorably by the Board of Regents of the University and the purchase of this stallion was duly authorized. After long delay in making this authorization effective, the whole matter was finally indefinitely shelved.

Our efforts in the direction of poultry and hog work have encountered similar experiences. Inability to obtain the stock necessary for sound experimental work has been an almost insurmountable obstacle. The fact still remained that it was absolutely essential for us to know the exact conditions surrounding and controlling pork production in these Islands. The amount of corn necessary to produce a pound of pork most economically, when used in connection with many different types of pasturage possible in these Islands, the relation of different feeding methods to the production of pure breeds, the greatest possibilities of success in grading under these various feeding systems, were all matters absolutely requiring thorough investigation before any positive step could be taken in exact instruction or extension work. Especially desirable was it that this work should be carried out, as far as possible, from the viewpoint of the small farmer whose areas and facilities were limited. Therefore we introduced into our plan a large series of experiments with small pasture plots handled in rapid rotation and we immediately embarked in this work with all such pigs from our herd as were in a good state of health at that time. During the first year of the work of the College, the herd was free from kidney worm. The kidney worm was, however, introduced with some pigs obtained from the Alabang Station and thereafter it became necessary to frequently examine the whole herd and isolate the infected pigs. In the future continuation of this work the present herd will be entirely disposed of and the new work carried on in a widely separated portion of the farm on uninfected ground, and still greater care will be taken in connection with this pernicious disease.

Out of numerous results obtained during the earliest years of this work there is much that cannot now be elaborated for presentation but it is thought that a recounting of some of the results at this time will be of interest and of value to all who may be interested in this important work. It may be remarked that the students of the College of Agriculture had first-hand connection with all that has been done here and have had all of the advantages connected with an exhaustive study of the work while it was in progress. It has not been difficult in this locality to prove beyond any question, even with the many difficulties under which we have labored, that it is readily possible to produce far greater profits per hectare in the raising of pork than is possible to farmers of the region in the raising of cane as that work is carried on here at present. It has not been difficult also to prove that the possibilities in pork production by the use of properly rotated small pasture plots

is far greater to the small holder than anything yet dreamed of by Filipino farmers.

RESULTS WITH CORN AND PASTURE PLOTS

For a beginning test of this kind twelve pigs were used, five of which were farrowed November 28, and seven December 4, 1912. They have been allowed free range part of the time on peanut pasture and were strong, thrifty pigs. Their weights in kilograms were as follows:

In this test the price of corn is figured at 2 centavos a pound, while the actual price of corn at that time was less than 1.5 centavos a pound. The corn contained between 89 and 90 per cent of solid matter. These pigs were castrated and weaned when the test began and the gains are not flattering on that account. Twenty per cent of the weight of the pigs is taken as offal and the remainder figured at 25 centavos a pound.

Number	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
February 18	15.4	11.4	13.6	13.4	12	21	14.4	20.4	10.8	19.8	24.4	10.8
March 6	17	12.8	14	15.8	13	23.8	15.8	24.6	13	20	26.2	12
Gain	1.6	1.4	.4	2.4	1	2.8	1.4	4.2	2.2	0.2	1.8	1.2

The total amount of corn fed to these pigs was ninety-six pounds while the area of the pasture which was planted to mongoes (20 m. × 27 m.) and cowpeas (6 m. × 27 m.) was 0.0702 hectares. These pigs were of course weaned at the beginning of the test and the males were castrated. A summary of the results is as follows:

Total gain of twelve pigs in 16 days, 20.6 kos., 45.4024 lbs.

Gain per day for each, 0.1073 kos., 0.23647 lbs.

Total amount of corn fed, 96 lbs.

Corn fed per pound of gain, 2.13 lbs.

Credit pasture per pound of gain, 3.46 lbs. corn (1).

Value of 0.0702 hectares of pasture in corn, equivalent 156.546 lbs.

Total cost of 45.4024 lbs. gain, in corn, when corn alone is used for feed, 254.2534 lbs.

Value of that amount of corn at 2 centavos a pound, ₱5.085.

Cost of corn alone (5.59 lbs.) to produce one pound of gain, ₱0.112 (2).

Value of one hectare of cowpeas in pounds of corn, 2244.24 lbs.

Value of corn at 2 centavos per pound, ₱44.88.

Pounds of pork per hectare of pasture, 400.7 lbs.

Actual value of pasture per hectare for producing pork, ₱80.15.

The second pasture test was with cowpeas and followed immediately the above. The field was drilled to peas in rows two and a half feet apart, and the peas were excellent, having a large amount of grain. The weights in kilograms were as follows:

Number	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
March 6	17	12.8	14	15.8	13	23.8	15.8	24.6	13	20	26.2	12.
March 24	21	15.6	19.7	19.4	15	29.6	18	27.6	15	24	31	14.4
Gain	4	2.8	5.7	3.6	2	5.8	2.2	3	2	4	4.8	2.4

(1) This figure is obtained by the use of Henry's constant (*Report Wisconsin Station, 1907*) for 9 to 12 weeks pigs, which is 5.59 lbs. of corn for each pound of pork, in the case of a ration consisting largely of corn.

(2) Compare these figures with recent results (from *Florida Station Report, 1914*) showing costs of production per pound of part corn-fed pork, ranging from 30 to 48 centavos.

Total gain of 12 pigs in 18 days, 93.23 lbs.
Total weight of corn fed, 184 lbs.
Gain per day for each pig, 0.432 lbs.
Total cost of the corn fed, ₱3.68.
Value of pasture on corn basis, ₱338.
Value of 338 lbs. of corn, ₱6.76.
Total cost of 93.23 pounds of pork, ₱10.44.
Cost of one pound of gain, corn basis, ₱0.112.
Value of 93.23 lbs. of pork at 25 centavos a pound less 20% offal (74.58 lbs.), ₱18.65.
Area of the cowpeas in hectares, 0.081.
Corn basis value of 0.081 hectares of cowpeas, ₱6.76.
Value per hectare from a corn basis, ₱83.46.
Pounds of pork credited to the cowpeas, 60.35 lbs.
Actual value per hectare, ₱149.01.

The pigs ate the peas first and afterwards the leaves of the plants until only the main stalk of the plant was left. A second crop immediately started to grow and was pastured down later by the pure bred Berkshires. Could this crop have been used later by the same pigs the results would have been still more flattering. However, since the conditions are not always such that a second crop can be utilized, it was thought best not to use it.

The test following lasted 19 days, but the peas were over-ripe and did not make such good feed as in the previous test. The respective weights are as follows:

Number	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
April 20	33.3		29.3	27.5		45.3	29.2	36.7	22.5	37.7	46.7	23.3
May 10	39.2		38.2	36.2		52.3	37.4	44.8	30.8	46.0	53.8	29.2
Gain	5.9		8.9	8.7		7.	8.2	8.1	8.3	8.3	7.1	5.9

Total gain of 10 pigs in 19 days, 170.5896 lbs.
Average daily gain per day for each pig, 0.89784 lbs.
Corn necessary to produce a pound of gain, 2.26 lbs.
Credit cowpea pasture per pound of gain, 3.33 lbs.
Value of 0.08 hectares of cowpea pasture in corn, 369.8 lbs.
Total amount of corn fed, 387 lbs.
Increase in weight credited to pasture, 101.7 lbs.
Value of one hectare of cowpea pasture, ₱254.25.
Value of 0.08 hectares in pork at market, ₱20.34.
One hectare will produce, pounds of pork, 1271.6 lbs.
Amount of pork credited to 0.08 hectares of cowpeas, 101.73 lbs.
Value of the cowpea pasture on a corn basis, ₱142.37.

In this test the pigs had better access to shade than in any of the other tests.

On the morning of April 9th the pigs were turned into a new plot of cowpeas. This was the best plot of the entire field, but at all times the pigs had all they could eat of the vines. The weight and the final results of this test are given below:

Number	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
April 8	27.2	18	23.8	23.6		37	24	33.2	18	33	39.2	19.
April 20	33.3		29.3	27.5		45.3	29.2	36.7	22.5	37.7	46.7	23.
Gain	6.1		5.5	3.9		8.3	5.2	3.5	4.5	4.7	7.5	3.9

Total gain of ten pigs in ten days, 117.03 lbs.
Gain per day for each pig, 0.975 lbs.
Corn fed per pound of gain, 1.88 lbs.
Credit cowpea pasture per pound of gain, 3.72 lbs.
Value of 0.81 hectares of cowpea pasture in corn, 435.4 lbs.
Total amount of corn fed, 220 lbs.
Corn required to produce 117.03 pounds of gain, 655.37 lbs.
Value of that amount of corn at 2 centavos a pound, ₱13.11.
Value of one hectare of cowpea pasture on a corn basis, ₱107.50.
Number of pounds of pork one hectare of cowpeas will produce, 959.87 lbs.
Actual value of cowpea pasture per hectare, ₱191.97.

There were eleven pigs in this lot, but one died on the day the pigs were weighed. This was unfortunate since the results under more favorable circumstances would have been even better than any of the previous tests.

Just after being weighed out of the second test, No. 5 pig died. The cause of death was kidney worms in the lungs. During the third test there were only 11 pigs in the test. The results of the test are given below:

Number	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
March 24	21	15.6	19.7	19.4	15	29.6	18	27.6	15	24	31	14.4
April 8	27.2	18	23.8	23.6		37.	24	33.2	18	33	39.2	19.4
Gain	6.2	2.4	4.1	4.2		7.4	6	5.6	3	9	8.2	5

Total gain of eleven pigs in 16 days, 134.66 lbs.
Gain per day, each pig, 0.755 lbs.
Corn fed per pound of gain, 2.338 lbs.
Credit cowpea pasture per pound of gain, 3.26 lbs.
Value of 0.76 hectares of cowpea pasture in corn, 439 lbs.
Total amount of corn fed, 315 lbs.
Total corn requirement for 134.66 lbs. gain, 754.09 lbs.
Value of same at 2 centavos per pound, ₱15.08.
Cost of one pound of gain, corn basis, ₱0.112.
Value of the cowpea pasture on corn basis, ₱115.52.
One hectare produced, pounds of pork, 1029 lbs.
Actual value of cowpea pastures per hectare, ₱205.75.

The corn fed was common native corn of good quality. A box of charcoal mixed with crushed rock salt was placed in the lot so the pigs could eat at will.

The pasture was drying so there were many dry leaves on the bottoms of the plants. Ninety per cent of the peas were ripe. Enough peas were taken from the vines to re-seed the plot. The pigs preferred the peas to the corn and did not eat corn as long as the peas were plentiful. None of the pigs showed signs of sickness and all ate well throughout the test.

RESULTS FROM A RICE BRAN AND PASTURE COMBINATION

The following table gives the weight in kilos of seven pigs and different dates of the experiment.

Date	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*Total Weight, Kos.*
Nov. 2, 1912	76	57	63	60	64	74	75	469
Nov. 16, 1912	79	60	67.6	63	66	77.2	78	480.8
Dec. 7, 1912	84	64	72.8	65	69.6	82.8	84	522.2
Dec. 21, 1912	86.6	67.8	75	67.4	73	85	87	541
Jan. 26, 1913	93.4	79.4	93	77.4	81	93.2	97	612
Feb. 17, 1913	108	79.4	97	79	84	101.4	113	659

The rice bran consumed amounting to 26 cavanes was bought from Calamba, October 26, 1912, at ₱1.55, amounting to ₱40.30. After it was consumed we bought eight cavanes at ₱1.00 each, ₱8.00; and then bought again 30 cavanes at ₱1.10 per cavan for ₱33.00.

At first they were fed two pounds each a day but they could not eat one-half so much and so they were given one pound a day. Not long after, they became accustomed to this feed and so were again given 2 pounds, and this was increased gradually to as much as four lots a day. Beginning from January 26, after weighing, they were given as much corn as they could eat, this because we wanted to sell them as soon as possible.

February 17th, they were sold at

20 centavos a pound; deducting 20 lbs. for every 100 lbs. this amounted to ₱234. Rice bran consumed, 1,742 pounds. The average price per cavan equals ₱1.25. One cavan equals 55.10 pounds.

Weight of hogs at beginning of experiment, 469 kilos.

Weight of hogs January 26, 612 kilos.
Total gain in 85 days, in kilos, 143.
Total gain in 85 days, in pounds, 315.172.
The amount of rice bran consumed in 86 days, in pounds, 1,742.

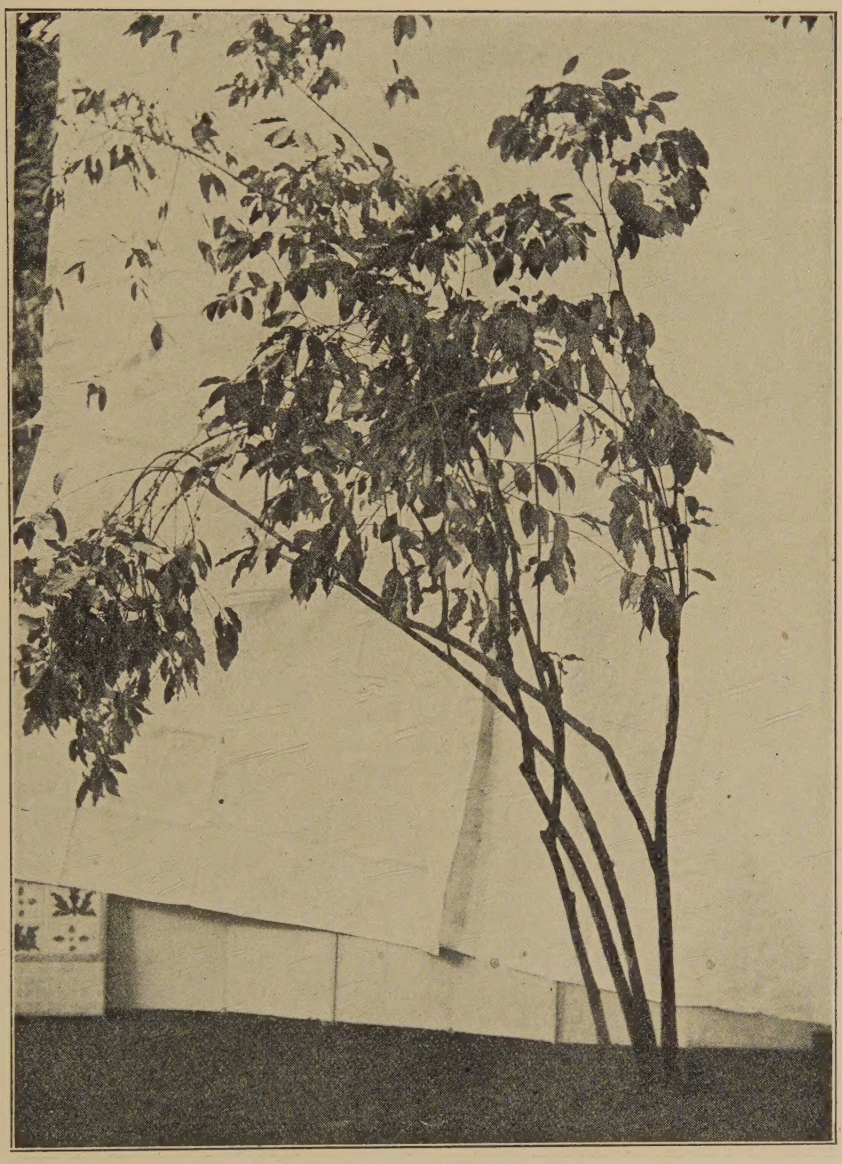
The amount of rice bran fed to make one pound of gain, 5.52 lbs.

Or one pound of gain costs 5.52×0.0223, ₱0.123.
Gain at the end of the experiment, ₱62.92.
Cost of the feed consumed, ₱39.5434.
Gain of seven hogs in 86 days, ₱23.3766.
Average gain of seven hogs per day equals 3.65 lbs.
Average gain of one hog per day equals 0.521 lbs.

The above results will indicate to some extent the enormous importance and interest of this work. It is perhaps needless for me to say that it should be continued as rapidly as possible and on a far more comprehensive plan than has yet been possible.

It has been my good pleasure at the College of Agriculture to train numbers of students in such manner that they will be able to furnish efficient assistance in the further prosecution of the work. While I am at this time resigning from the College to leave the Islands permanently, I am leaving such data as I have been able to gather and I am leaving the fully elaborated plans covering the continuance of the work which I have mentioned above. While the present notes are not submitted as finished results in any sense, still they will have served their purpose if they help to make clear the nature of the work and the striking urgency of it in connection with the development of Philippine Agriculture.

PLATE I



SPRAYED TREE IN HEMILEIA SEASON